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Writing a Scientific Paper

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In 1970 Vernon Booth was awarded the first Prize in a competition organized by Koch-Light Laboratories Ltd, Coinbrook, Bucks., U.K.. His article 'Writing a Scientific Paper' was printed first in 1971, and 10000 copies were distributed freely by Koch-Light. A Second Edition was prepared by Dr Booth and distributed privately. Copies of the First and Second Editions are no longer in print but requests for them have not ceased. Hence this Third Edition, which is a revision of the previous versions.

Preface

This essay is not a complete text on 'How to write ...'. Nor is it designed - to replace existing works on literary style or the editorial directives issued by journals. Rather it is intended to help research students and scientists to avoid faults; in particular, faults I have encountered in scientific papers. Most of the notions are not new but seem to need repeating; some may be novel. I am grateful to a dozen colleagues for their comments and suggestions.

Parts of the essay are written in the imperative, the simplest style. It is not intended to be categorical. True, certain parts are controversial - but life would be dull if we all agreed. There may be errors: most books have errors. I feel tempted to add — as an examinee once added - E &OE (Errors & Omissions Excepted).

If you dont have time to read the whole essay, do look at **Literary style**, **Choice of words**, **The typescript** and **Units & quantities**.

Examples of a directive being discussed are referred by the sign ✔.

Before you write

Good note-book discipline is enormously helpful. When you have finished an experiment, try to record your conclusion in words on the same page with your findings. Make tables. Draw graphs and stick them into the book. Keep a separate book in which to record summaries of results from many experiments and group them by subject. Some experiments will provide results for several summaries. Not only are well-ordered note-books useful when you write a paper, but the prompt recording of summaries compels you to give critical thought to each experiment at the best time, and may move you to repeat a control test while you still have the materials. Kitson Clark (1960) makes an eloquent appeal for keeping adequate notes.

Some laboratories operate a tea club or seminar through which researchers tell colleagues about their work. Speaking makes you think out arguments; and listeners' criticisms may prevent your publishing a danger. If your institute has no club, or its programme is filled, invite colleagues to your room to listen to you. Display diagrams. If you have no projector, use a felt pen to draw diagrams and tables on the back of a roll of wall-paper. Hang the paper over a chair placed on the bench. Do speak slowly. Nothing clarifies ideas so much as explaining them to other people.

The third suggested pre-writing activity is based on Woodford's (1970) 'reservoirs'. Take six large sheets of paper. Boldly label them **Title, Summary, Intro, Meth & Mats, Results, Disc.** Write your ideas for the paper, as notes, on the appropriate sheets. Whenever ideas come to you, write them down, in any order. Use differently coloured sheets if possible.

Carry a card everywhere. Jot down ideas as they occur. Transfer the notes to the reservoirs and put a fresh card in your pocket.

Some writers construct a skeleton, an outline scheme, before they start to write. Should you do this it is still advisable first to prepare reservoirs as above. A skeleton for the **Discussion** may help you both to avoid repetition and to muster your ideas in the best order.

When to begin writing

My research supervisor said *'Writing a paper is as important as experiments. Is it unreasonable, then, if it takes as long?'* Oft-repeated advice is *'Set aside your paper for some weeks, then read it. You will be amazed ...'.* You may even discover a passage you yourself cannot understand. If you follow this advice you must start writing early. Writing as the work proceeds reveals gaps in knowledge to be filled while laboratory facilities are still available.

Arrangement of a scientific paper

Although there is no standard arrangement for a scientific paper - and people hope there never will be - the traditional forms have merits. I shall base my suggestions on the commonest form. Most journals print results before discussion, but some print the experimental part in small type at the end. Some investigations are suitable for results and discussion to be written together in narrative form. Many journals issue editorial directives that leave you no choice. Examine the chosen journal and arrange your paper accordingly: dont give the editor (perhaps unpaid) needless editing.

Where to start

Even though you have the material, you may have postponed writing a projected paper. Perhaps you find it difficult to start. I do. You dont have to begin with the **Introduction.** Begin with the easiest section. This may be **Methods,** for you should know what you did. Use the reservoirs, and cross out the notes as you consume them. Next prepare a table, and describe the **Results.** Then another....

Write the first draft 'in your own words' as though you were telling a friend about your work. Dont worry - yet - about grammar & style. The important objective is to 'get going'. You can polish the style later. That is what I have done in this paragraph without yet polishing out the cliches or needless words.

Title & key words

Some searchers may read only the **Title** and the **Summary.** So both are supremely important. Compose them early; re-examine them later. The longer they rest, the greater your potential shock.

On your reservoir sheet make a list of *key words* for the **Title.** Let the **Title**'s first word be a key word if you can - in lists of titles such a word is better than 'The'. Although desirable that the **Title** be short, it should not be general. A reader, attracted by a title, may be disappointed to find the paper is about only one specialized aspect.

Many journals require additionally a short 'running title'. An ingenious paraphrase of the Title can supplement the latter. For example I have seen the Latin name in a title and the common name in the running title.

If the journal prints a list of key words, you caa select them from your reservoir.

Summary or Synopsis

If the editor permits, compose the Summary in numbered paragraphs. The first should state - briefly - what you did. Then come the main results. Dont give indigestible lists of values. Use words if you can, supplemented by a few key values, or reference to a table if it contains material that others will use as data for argument. State you conclusion in the last paragraph. If you have no plain conclusion, you might write 'The effect of A upon Â is discussed'. Remember that, if a summary is long, yet constructed as above, readers may look only at the first and last paragraphs. Although a well-written summary may be lifted by other people into abstracts, a long summary will be shortened, perhaps by the omission of what you consider vital parts.

Write the **Summary** in the past tense, except perhaps the last paragraph. Place the **Summary** at the beginning of the paper if its position is within your control. That is where you like to find a summary, is it not?

Introduction to a paper

The **Introduction** should state the problem, refer to published literature and perhaps ask a question. The objective must be clear. If you modified your objective after you began the experiments, give the current versiop. In the last sentence it is good practice to state your conclusion, but only briefly. A reader can better appreciate the evidence that follows if he knows what conclusion it is supporting.

It is no longer good practice to quote many papers. [If much has been published, and you think it warrants - yet you cannot find - a critical review, write that separately and submit it to an editor.] Refer to papers that, taken together, indicate that a problem exists. If another paper gives many references, refer to that. However, beware of lifting references - from that paper - together with misquotations of information from the original papers. It has been done.... See the second paragraph under **Emotion & modesty**.

Materials & Methods

If the description of materials is brief it may be included in **Methods.** Avoid trade names if practicable; not to avoid advertising, but because they may not be understood abroad. [Do you know what *Skellysolve* means? The name occurs frequently.] If, for *polymethyl methacrylate* or other compound, you use a local name, give the chemical name at first mention of the trade name.

Write what you did in operational order. Invert 'The absorbance was read after filtering'. You should so describe the methods you used that others can repeat the experiments. Although you must be concise you must not omit essential detail. Be precise. If a tube was heated, say to what temperature. If you controlled, or even measured, the humidity and ventilation in an animal room, say so: they are nearly as important as temperature. If you performed chromatography or other process at a slower or faster rate than is usual, state the rate.

If you used controls, permit no doubt about their nature. The reader may not be able to guess what you omitted for each control.

Resuits

As you write about your **Results** it may be advisable to study **Units & quantities** and **Tables.**

Replicate observations should not usually be given. It is better to offer the mean and a measure of the variability. The range is not satisfactory: if there are enough replicates for the range to be of use then there are enough for estimating the standard deviation of one observation (S.D.), the stand error of the mean (S.E.M..) or the coefficient of variation (C.V.). Give the number of observations or the degrees of freedom within parentheses thus: 12.65 ± 0.22 (12). It is even better if you can make a pooled estimate of the variance (or other statistic) from the whole experiment.

Editors require tables and figures to be clear without reference to the text. The converse has also been expressed: the text should be clear without the tables. If you can achieve that high ideal, read no further: you have no need of my suggestions!

Discussion & Conclusion

The **Discussion** is the part of the paper in which you have greatest freedom. The **Discussion** must not be so long as to deter a potential reader, yet it must contain logical argument. Dont repeat descriptions of other people's findings if they are in the Introduction: refer to that. Avoid summarizing your results in the **Discussion**. Mention them, take them as read or refer to a table or even to the **Summary** (quote the paragraph number) for others. Enlarge upon their significance and explain how your new results add to existing knowledge. If, in the Introduction, you had formulated your problem as a question, discussion is facilitated when you can give the answer.

Think critically. Not only about other people's work, but about your own. For example, ask yourself *'Can my hypothesis be refuted? Can my results have another explanation?'* Forty years ago, the students in one of two large groups were told that, were they unable to solve the problem given to them, they should try hard to ignore their first approach and seek a different line altogether. This worked, yet it is difficult indeed to achieve such lateral thinking' as its modern development is called. The following example shows how important is such *'no-prejudice rethinking'*. Two authors published graphs to prove their thesis that xanthineoxidase and the Schardinger enzyme (aldehyde oxidase) are distinct enzymes. Later their graphs were used by another author to confirm the opposite (now accepted) view that the enzymes are identical. Had those first authors given their results more thought, they too might have reversed their conclusion. The literature contains abundant examples of inconclusive thinking. Writers should take care not to add to them by publishing in haste.

Conclusion. If you are fortunate, your Message, or part of it, may survive in text-books—although you may not be given a whole sentence! So the **Conclusion** needs meticulous wording. This may appear - legitimately - three times: in the **Discussion, Summary** and **Introduction.**Dont repeat the wording; paraphrase it. If the reader has not understood, another version may help him.

References, Bibliography or Literature cited

Write each reference on a card. Arrange the cards in order and give them to the typist at the final typing of your paper, This scheme leads to less errors than does retyping the references

at every retyping of the paper. Check the typed list against the original papers. Also check that spelling etc. in text and **Bibliography** agree. Inconsistencies and errors are *very* common in papers as submitted to editors. Please read the last sentence again. (See **Numbering**)

Literary style

Written English at its best is virtually the same as spoken English at its best. Grandiloquent writing - in science - is no longer fashionable. What we have to do is to convey ideas effectively, to make it easy for the reader to understand what we write, not to impress him with our vocabulary. Indeed, writers who use pompous language may even be under suspicion of having nothing important to say! Try to envisge your readers. Write especially for them, in a manner not too technical, not too elementary.

Clear English. Ask yourself often *'Would a reader whose first language is not English understand what I write?'* Use ordinary words and simple construction. Write short sentences, but not all of them so short as to produce a staccato effect. Cure a staccato passage by linking two sentences (as I have done here with a 'but'), but do this infrequently, so as to keep to *'one idea per sentence'* with only occasional exceptions. It will help you to develop a good written style if you train yourself to speak well. In conversation speak slowly, choose words deliberately, finish each sentence. You should be able to offer more information per unit time than can he who talks fast but interjects 'you know' or 'anderm' and runs his phrases into almost interminable sentences padded with empty words.

Incomprehensible sentences. In courses on rapid reading, one is warned not to go back to re-read a passage. A trained reader may not permit himself to return to a difficult sentence, and so fails to grasp its meaning. How can you discover such passages in your writing ? One way is to put the paper away for a month. This may be impracticable if you have a completion date (as I have). Another is to have a colleague read your paper: ask him both to make general comments and to mark every sentence he had to read twice. If he seems too critical, thank him nevertheless : should he fail to understand you, others might too, and your Message is lost.

A passage that contains a comparative sometimes causes difficulty; for example the effect of two agents under two conditions. Make clear what is greater than what. Instead of '... the starch yielded more glucose than maltose' say either '... than did maltose' or '... starch produced a greater yield of glucose than of maltose'.

Never begin a sentence with a long qualifying phrase. First make the statement, then water it down. Say '... a precipitate formed, although in ...'. Avoid long adjectival phrases, because the reader has to store them mentally until he reaches the noun. For example 'a frequently heated and therefore deeply coloured viscous ...'. Woodford (1970), too, denigrates such 'stacked modifiers' as he calls them.

Noun adjectives can sometimes be avoided with advantage. The following phrases are inelegant: 'albino rat liver xanthineoxidase activity'; 'pH4.4 buffer'; 'apparatus construction'. It is better to write 'administration of drug' than 'drug administration'; and 'treatment of the product' than 'product treatment'. If you dislike recurrent 'of', the occasional possessive case may be permissible. In 'dog meat' or 'cat fish' make it clear which of the two possible

meanings is intended.

It is not suggested that nouns should never be used adjectivally. Many are so used satisfactorily, including: hydrogen bond, gold size, egg albumen. Indeed such terms would be clumsy if turned.

Please note that *in vivo, in vitro,* excess and *de novo* should not be used as adjectives, but that sub-liminal, optimal, minimal, maximal, enzymic should. Write 'tests *in vivo*' not '*in vivo* tests'.

Wrongly attached participle. One of the commonest errors submitted to editors is exemplified by 'having completed the observations the telescope was ...' or 'using a pipette, solutions were measured'. Who used the pipette? 'After standing in boiling water for an hour, examine the flask' makes people laugh, yet such errors (aberrations, faults, lapses ...) are frequently submitted to editors. It is worth reading what Fowler *(*Modern English Usage) or other authority has to say on unattached participles. This deviation is also called a Dangling participle, a good description because nowadays so many sentences start with 'Judging by' or 'Based on' that these may be in process of becoming modern usage ✔. So let words that end in -ing or -ed be Warning Words.

Pronouns. When you write 'if', 'this' or 'they', are you sure the meaning is plain? A pronoun deputizes (usually) for the nearest previous noun of the same number (singular or plural). If you have used a pronoun for a more distant noun, perhaps the noun should be repeated, as 'summary' is above ✔. Possibly 'them' is wrong in text below ✔.

The occasional 'I' need not be shunned. Repeat occasional. Indeed, if you quote published results and then include your own, claim the latter. 'The author' might mean him not you. If a personal pronoun seems out of place, the change from his work to yours may be indicated by the words 'in the present experiments', but elaborate avoidance of 'I' may look clumsy. You would never, of course, write 'we' for yourself, nor use 'I' immodestly.

Pudder. If you put aside your draft, then examine it later, this is the time to remove needless words.

Such phrases as 'It is worth pointing out in this context that' may be deleted without affecting the meaning.

So may 'It is significant to note the fact that', 'found to be', 'It should be borne in mind in this connexion that', 'relevant to mention here' and other phrases that correspond to no more than spoken 'er hums'.

For 'It is plainly demonstrable from the data presented in Table 2' write 'Table 2 shows'.

If a piece is introduced by 'Needless to say' why say it? 'Recent' is usually redundant - let the reader decide.

Usually 'we were able to see' or 'could be demonstrated' means 'we saw'; 'could find' means 'found'; and 'proved to be' means 'were'.

'Concerning' may be cut to 'on','therefore' and 'consequently' to 'so'. Indeed, 'so' is a

neglected word.

'Make every word count.' Each of the following phrases may be pruned to one word:

clearly shown;	period of time;	red in colour;	completely full;
very similar;	would appear;	both of;	pooled together;
quite unique;	whether or not;	right now;	foot pedal;
first of all;	exactly true;	face up to;	by means of;
definitely proved;	in order to;	in an exhausted condition;	
given data;	wholly empty.	positive action;	

Avoid repetition of the type 'may be .... probable', 'seems that ... could be possible', or 'it is supposed it might ... in some cases'. Such *double hedging* weakens discussion.

Tense, mood & voice

Undisputed knowledge requires the present tense. An author usually writes about his new work in the past tense. Other people's work is variously reported: the past tense may be most suitable. (See **Summary**)

Working directions for a method are sometimes written in the imperative mood. This is done, not in the sense of giving commands, but because it is the most direct style.

The passive voice, although much used to describe results, sometimes makes clumsy construction. Turn a passive phrase to direct style whenever you can. For example 'pH4 is needed for the enzyme' may be turned to 'the enzyme needs pH4'; 'it has been reported by Pass' is better written as 'Pass reported'; and 'distillation was involved in the method' should be 'the method included distillation'.

Choice of words

Do beware of using words whose true meaning is not what you wish to convey. When you write 'fact' do you truly mean agreed certainty? Effect, hypothesis, observation, value, result, phenomenon or finding may be more modest. 'These facts' may even be changed to words that give information: 'These similarities'. 'Due to the fact that' is better written as 'Because'. 'In spite of the fact that my results were negative' is bettered on several counts by 'Despite my finding no response'.

I suggest that you look up 'data' in a dictionary. Preliminary results and unpublished findings are not yet data. Data is plural, as are media, agenda and phenomena.

'Parameter' is sometimes used wrongly. Variable might be safer. If you are unsure about 'which' and 'that', recall the rule *'which describes, that defines'*. Consider the phrases:

brown hens, which lay brown eggs, have yellow ...
brown hens that lay brown eggs have yellow ...

The first implies that brown hens lay brown eggs and also have the yellow character. The second means that those particular brown hens that lay brown eggs have it. Confirm your decision through the comma: if one is needed, write 'which'.

'Constantly' is often used to mean no more than often. Continually, continuously, repeatedly, regularly or even frequently may be meant. Reserve 'constant' for unchanging. Write 'constantly changing' only if you mean exactly that. Only write 'invariably' if you really mean always; even better, write 'always'.'Varying', a Warning Word, means actively changing. The word is often used wrongly in place of varied or various ✔.

'Efficient' describes processes whose efficiency can be measured. A writer may mean effective. You may have devised a shaking machine, a cutter or a warning device. Can you determine that it is efficient? A catalogue described a potentiometer-type power pack (for supplying desired voltages) as 'efficient'. An engineer who reads that such apparatus is efficient, yet knows it cannot be, may doubt the truth of other statements in the catalogue.

'While' should be restricted to its temporal meaning; try 'whereas' or even 'and'. Similarly, 'because' sometimes betters 'since'. Did an author really mean '*A* began each experiment while *B* finished it'?

The misunderstanding about 'due to' may be lessened by an example. We write 'the colour of the crystal was due to impurities' but 'owing to impurities the crystal was coloured'. If 'Due to' starts a sentence, that is probably wrong.

A chromatographic column of adsorbent is held in a tube: the tube is not the column. Confusion arises when a reader cannot tell whether a stated height is that of tube or column.

Rats are fed on meat, not fed it. One may feed an animal but one cannot feed a diet.

'Very few' is mildly absurd. 'Only few' may be better. The argument also applies to 'very rarely'.

It may be advisable to avoid writing 'like' for 'such as' or 'for example'. One reads of 'acids like acetic'. Do such acids exist? 'Relatively' should only be used in comparisons. Alone, it has no meaning.

It seems undesirable to use a mathematical term for a non-mathematical meaning if an ordinary word exists. For example dont write 'centre' (a mathematical point) if you mean middle; or 'degree' if you mean extent. For graphs write 'filled' symbol not 'solid'. 'All' is usually better than 100%. An area has two dimensions; 'circle' does not mean disk. 'Negative' is best kept for minus - there are plenty of words for none. It seems unscientific to use ± for with and without (when + or 0 is meant), and to use = without due care.

When you write the first words in the following list do you indeed mean the second, or vice versa?

Alternate (alternative) ✔	facile (easy, simple);
brackets (parentheses);	plug (socket);
generally (usually);	wire (cable);
u.v. light (radiation);	if (when, whether);
accordance (accord);	intensive (intense).

These are but a few of many words that are used wrongly. You may have words to add to the list.

Plain words. In general, use short rather than long words if they have the same meaning. Often this means using Anglo-Saxon rather than Latin words.

> Write 'after' not 'subsequent to' or 'following' ✔;
> 'have' not 'possess';
> 'before' not 'prior to' (prior is an adjective);
> 'use' not 'utilize' or 'employ' (employ implies payment);
> 'about' not 'approximately' or 'circa'.
> .'Show' may be better than 'demonstrate', 'disclose', 'exhibit' or 'reveal';
> 'enzymic' is neater than 'enzymatic''.

However, dont eschew a long word or a word from Latin if it conveys the meaning better than another; syrup is an aqueous solution that cannot be called watery ✔.

If you use foreign words when a short English word will convey the meaning, you risk being accused of affectation. (Brei, per capita, ipsofacto, a propos....) You also risk our failing to understand you. Sometimes the spelling or grammar is faulty: note that 'capita' is plural ✔✔.

Elegant variation. English abounds in near synonyms - different words with almost the same meaning. For example: enough, adequate, copious, plenty, ample, sufficient. Repetition of a word within a sentence is considered to be bad style, a fault avoidable with synonyms. But, in scientific writing, use synonyms only if the meaning is plain. Repeat a word if the sense so requires. There may be a case for a synonym where a technical word might not be understood by all, but it must be clear that the two words mean the same. It may be wise to write both words at the first use. Repeats may sometimes be obviated by rewriting a sentence. If a sentence has many 'and's, try replacing one of them by 'then'.

Homonyms. English also abounds in words having more than one meaning. Where possible, use a word with only one meaning. Never, in one passage, use the same word for different meanings.

Use 'normal' only for its normal meaning. 'Molar' describes solutions better than 'normal' because the former has only one meaning. 'Cell' is overworked, and 'cuvette' is better in spectrometry. 'Reduce' has two meanings. Avoid the word or clarify it as appropriate. Beware of such oddities as 'fixed in running water'. 'Figure' is used for picture, pattern, shape, number; digit or numeral; quantity or amount, price and value. It seems sensible to restrict its use to the first meaning. A number, such as 247, is composed of digits or numerals; 247 μCi/g is a value; 24.7 mg is a quantity. The abbreviation for ordinal 'Number' is 'no.'. Dont abbreviate cardinal 'number' to 'no.'. Say *'The number of trees on plot no. 6 ...'*.

Conveyance of ideas without element of doubt

I recommend that you read what Fowler or other authority has written on 'case'. Perhaps the sloppiest misuse is to make the word act as a pronoun - as 'in the above cases' - so that the reader has to go back to find what the cases were. I have met cases where I could not be sure to what experiments the writer referred, and many times I have wondered whether '2 cases' meant two experiments, two animals or two observations on one animal. So let case be a Warning Word. Replace it, if you can, by a word that gives information (for example 'this species' or 'Expt no. 8'); or shorten the phrase, as in these examples:

in most c. (usually, mostly);	in that c. (so);
in this c. (here);	in the c. of (for, in);
in all c. (always);	was the c. (was so, was true).
in no c. (never);	

You may think Fowler pedantic. But if you write in ultra-modern idiom, or in revolutionary style, may I plead as follows ?

First, convey your Message clearly. J.R.Edisbury *(Practical Hints on Absorption Spectrometry,*Hilger & Watts, London, 1966) writes in a breezy style, but his meaning is plain. (See also Dixon, 1973.)

Second, dont be conservative about names and units. We have discarded fuming spirits of muriatic acid, proteid, vitriol, probable error. So let us abandon formalin, formol, soda, glycerine, ml, pet. ether, potash.

Third, please dont add nails to the coffins of useful words. We have almost lost 'very', formerly a very useful word. Consider that last phrase: did the second 'very' affect the meaning? The demise is hastened by such thoughtless uses as 'very flat' and 'very level', yet there are times when we need the word ✓.

The use of 'quite' is reversing: 'his method is quite good' now means less good than 'good'.

So with 'certain': 'a certain amount' usually means an imprecisely known amount.

'Release' formerly meant allow to go. But now it is used to mean publish, that is push out, as in 'Provisional data release'.

'Surely', 'doubtless' and their synonyms no longer mean without doubt; 'no doubt' they will go.

The distinction between 'which' and 'that', which could be useful, is barely viable.

'Locate' and 'localize' should have different meanings.

Other words in mortal danger are discussed elsewhere: they include constantly, fact, column, efficient.

I appeal to you to use words with circumspection.

Language in flux

English is changing. This is desirable to meet changing needs, but it is not desirable to lose the meanings of useful words. When a new word is needed it seems better to coin one than to add to the mass of homonyms by taking an existing word. An example of such invention is 'capacitor' to replace 'condenser', which has other meanings. We need a word for s.e.m. - why not 'sem'? Another could be 'andor' to avoid the algebraic 'and/or'. But let us shun such horrors as 'hospitalization' and 'uniformization'. Words that end in 'ize' (finalize) or 'ization' should be Warning Words. Certain changed usages are common and may even become established. Examples now occurring include:

'aliquot' to mean *any* measured amount;
'assuming that' without a subject;
'if it was';
'a number were';
'a tube 90 x 10mm';
'under circumstances';
'ultraviolet light';
'detergents and soap';
'significant' not qualified by 'statistically';
'due to its viscosity it will';
100-volume H_2O_2';
'restructured';
'heighth';
'to author a book';
'caustic','medical','high' and other adjectives used as nouns ✔.

The first of these examples *may* be acceptable, or even desirable. Others are not. No doubt you could add to the list, but do you find the trend agreeable?

Good workmanship endures

If the conventions of literary style seem over fussy, do bear in mind that the difference between 'ordinary' writing and good writing is akin to the difference between an ordinary instrument and one that is very well made. Craftsmanship takes time to learn but is worth the effort.

The object of the writer should be to convey information with minimal effort from the reader. Although grammatical customs, like etiquette, are not all logically defensible, if you ignore them you may obscure your meaning.

Revision of the script must not be hurried

Read only a page of typescript at a time. The intense concentration needed cannot be maintained for long. While you read, imagine that foreign reader looking over your shoulder (see above). What you have written should make sense, not only as you read it, but when you read it aloud. Make it sound like intelligent conversation. Where you pause, insert a stop.

Critical revision is more necessary than writers realize. Even some of the articles on writing that are listed below contain lapses of style. There was a grammatical error in the first edition of this essay ('prevent you publishing' should have read '... your ...'). So do be vigilant. Let your aim be to make such people as myself redundant.

Extend your vigilance to repetition as well as to style and sense. In some papers, the introduction and the introductory part of the discussion contain almost identical passages. Parts of a method are sometimes described a second time in Results, in a legend or in notes to a table. Much of such repetition may be avoided, although occasionally a small duplication may be allowable. As I have written above, if your Conclusion is repeated, paraphrase it. Other parts, too, whose comprehension is vital, may be said again differently, introduced perhaps by 'in other words'. Use this device sparingly, however, or you will be in trouble, and so shall I. ✔✔✔

A great deal of needless repetition and verbiage is to be found, even nowadays, in so very many published papers, yet it may be that the authors were completely unaware of their unnecessary repeats, a possibility that can be adduced as yet one more good reason for authors to ask a colleague both to read and to comment on their scientific writings. Write out the previous sentence and, as you write, prune it to less than half. It can be done. Please dont spoil it for others by marking the print.

Spelling

Some words have alternative spellings. For example, show, neuron, gray, acknowledgement, disk, neutralize, artifact. It seems sensible to use the form that better represents the pronunciation, if the choice is yours. Some words are spelled differently in U.K. and U.S.A. A few journals allow a writer to use either, but he must be consistent.

Stops or punctuation

The common stops may be considered to comprise a hierarchy: new paragraph, full stop (period or full point), colon, semicolon, dash, comma ✔. A lesser stop cannot govern (control, or take precedence over) a greater. An occasional exception is the dash.

In general, start a new paragraph when the subject changes. In good prose, one notion leads to another, which makes this rule difficult to apply. Because short paragraphs can look irritating, long ones boring, skilful compromise may be needed.

The colon is misused: its pause-length is between those of semicolon and full stop. Traditionally a colon does not end a sentence, but a full stop does. Therefore a colon should not occur after a phrase that refers to more than one sentence each having its own full stop. For example, if 'as follows' is followed by complete sentences, use a full stop not a colon. (See next sentence.) The following type of confusion is submitted to editors.

> The solution contained: glucose: 2g, NaCI: 3g and urea: 4g'.

Write:

> '...contained: glucose, 2g; NaCI, 3g; and urea, 4g'.

Similarly '... conditions (time: 25min, weight: 8g)' should have its comma replaced by a semicolon and its colons by commas. No sentence should contain two colons. Some writers would banish the colon; yet it can have a real use.

Semicolons separate two or more related clauses. Many examples appear in this essay. For an example that shows the distinction between colon and semicolon, see below ✔.

Commas are used in pairs, as here, to enclose a parenthetical remark. The latter is treated more fully below.

Children used to be taught not to put a comma before 'and', and this prohibition persists. In the phrases 'acids and alkalis' and 'powder was weighed and added' no comma is needed. The 'and' is the joining or catalogue variety and could be represented by &.

There is another kind: 'the cats were fed on meat and worms were given to the fish'. Your probable hesitation could have been avoided had a comma appeared after 'meat'. Another example: '... is dissolved in 5M NaOH and 2M KOH is added'. And another: 'The chairman was the head of the physics lab and the principal of the maths lab was elected vice-chairman'. So, when two sentences are linked by 'and', a comma shows that they ***are*** two sentences. Curiously, the ban does not extend to the comma before 'or', or before 'but'. A comma is needed before an 'and' that separates negative and positive notions, as in 'Dont write too much between full stops and present the information in small packets for easy understanding' and in 'The alloy is made by adding Sn to Pb and Zn is rigorously excluded'.

Where two adjacent nouns belong in different clauses separation should be achieved with a comma - for example after 'clauses'.

Dashes. The four symbols, hyphen (-), en rule (or en dash) (-), minus (-) and em rule (—), are all represented on the typewriter by one sign popularly called a dash. The meanings of the hyphen and the em rule (or long dash) are opposite: the hyphen joins words or pieces of a word; the em rule pushes words apart with a pause rather longer than that signalled by a comma. Because each sign is useful and has its own meaning it seems desirable to preserve their identities. The en rule has various uses including that in 1967-75. But write 'from 2 to 28' not 'from 2-28'. Spaces are not needed.

The hyphen has often had an essay to itself. Because the recommendations cannot be condensed to a few lines I shall not attempt the task. But I offer some suggestions and examples.

A hyphen is used to join words adjectivally: if a hypothesis is well known it is a well-known hypothesis, for example the all-or-none hypothesis. Dont join adverbs that end in -ly. Write 'vitamin-deficient and little-used diet' but 'a rarely eaten food'; also 'X-ray-induced and chemically induced mutations'. A hyphen can change a meaning: a large impulse counter is not the same as a large-impulse counter; note that the meaning would change were the hyphen omitted from 'little-used' above. Consult a recently issued and well-produced catalogue for hyphens in chemical names. Solutions are sometimes described thus -

> acetic acid-sodium
> acetate ethanol-formic acid-water
> mytomicin C-induced effect.

Avoid the confusion by writing 'a mixture of acetic acid and sodium acetate' or 'mixture of ethanol, formic acid and water (3:1:10)' or 'effect induced by mitomycinC'. The use of more en rules or more hyphens is hardly an improvement, and gives spacing trouble to the printer.

If you name a new material, for example 'Q virus' or 'HK mesons', do not use hyphens. Join a prefix (post-, non- etc.) to a noun by a hyphen. The foreign reader is then warned to look in the dictionary for the noun instead of starting with p or n.

Parentheses. A parenthetical remark (that is, an aside or explanation between two commas, dashes or parentheses, as here) within a sentence is not usually a complete sentence ✔. If it is complete, give it a capital letter and its own full stop, surround the whole with parentheses or square brackets, and place it after its parent sentence. Although '(Table 2)' may appear within a sentence, it is better for a longer phrase such as '(See for example Table 2.)' to be treated as a sentence. If the parenthesis is only part of a sentence, the full stop goes outside.

The solidus (diagonal) is used to mean 'per' as in wires/cable or km/h. Dont weaken the value of the solidus by using it for other meanings, such as dates, contractions or linkages as in NaCI/KCI mixtures. Avoid '5g/l of NaOH': the solution is not per litre of NaOH but of NaOH per litre. It is equally unscientific, though common, to write that 2mg/kg of a drug were given. Write '2 mg of drug per kg ...'.

The solidus brings mathematical formulae neatly into a line, thus: $(a + b^2)/2p$. A fraction that extends through two lines is typographically ugly and expensive.

Initial letters. A sentence should not start with a numeral ✔. If you find such a sentence, either rewrite it or spell out the number ✔. This practice is especially important at the beginning of a paragraph or when the previous sentence ends with an abbreviation, symbol or numeral. It is also undesirable for a sentence to start with a lower-ease abbreviation such as *p*-, a- or *n*-.

Abbreviations & cntrctns

Units - g, cm, mol - take no full stop, and plurals no s. No full stop is needed for Dr, Mr, Figs and some other contractions that include the first and last letter.

Some words - Miss, bus, taxi, rhino, laser, log - have been with us so long that few people give them stops.

Some abbreviations are ugly. 'Viz.' saves only two symbols from 'namely', and 'ca' from 'about'. 'Approx', too, is bettered by 'about'.

'Cf.', which does not mean 'see', can usually be deleted.

Special abbreviations, of long terms or chemical names that you refer to often, are best collected into a footnote on the first page. The full names need *not* be repeated in the text.

Headings or captions

As a novelist uses dialogue to make a page look interesting, so a scientific writer uses

headings and sub-heads. They help to make a paper readable, and guide the inquirer to parts he wants. Use many: an editor can more easily remove one than compose one. Unless the **Discussion** is short, give it sub-heads too.

Make your headings work. Be cunning. Perhaps you have used the in-other-words device in the text but still desire emphasis. Try to include the notion in a heading, but use different expressions in heading and text. (See ✔ on participles and ✔ on revision.) Simple repetition of a heading in the text is undesirable. A heading may ask a question ✔. The **Introduction** to a normal paper should not need that word as heading, which is as superfluous as 'Notice' on an obvious notice. However, if you can put information into it, then a heading here can be useful. For example, can you describe your problem in different words from those in the **Title**?

Tables

A table needs a title, probably supplemented by an explanation. The heading to each column should include units so that each entry is a number. If your quantities are large or small, use the prefixes M, m, p etc. Avoid using 'x 10^{-3}' in a heading because a reader may wonder have you divided by 10^3 or must he do so?

Indigestible tables with too many or too cumbrous numbers deter readers. Prune values even if you risk losing an occasional significant digit. Methods exist for calculating significant digits. The *s.e.m.* should not have *more* digits after the decimal than does the *mean.* Should the argument require many results from several experiments, and they cannot be further condensed or pooled, as suggested in **Results,** consider dividing them into two tables.

Any measure of variation offered must be defined without possibility of misunderstanding. Unfortunately *s.d.* and *s.e.* have often been used inter-changeably. In one paper submitted for publication, the *standard error* of the *mean* was so described several times) but the formula, given three times (in text, table and note), was that for *s.d.*!

Never forget that your calculated measure of variation only *estimates* that of the population, of which your results are a sample.

Are all your numbers correct?

If 'dependent' is misspelled the printer can correct that. If 265 appears for 205 a context may not help. Editors' time is wasted over incorrect page numbers, initials etc. actually seen, and no one knows the true total of errors. In a table it is unlikely that anybody but the author can check the values.

Illustrations

When an experiment has provided many observations these may be better presented graphically than as a table. Editors will not usually allow the same information to appear in both forms. For many people a diagram is easier to grasp and to remember than a group of quantities. The more values the better the basis of a graph, whereas many values in a table may confuse.

The horizontal co-ordinate of a graph represents what we select (time, weight, wavelength ...) and the vertical co-ordinate what we measure. If the origin of either axis is not zero, indicate this by a break in the line. A graph needs an indication of precision, such as an estimate of confidence limits, or symbols of a size to indicate the s.e.m.

Think logarithmically about dose-response curves and related subjects. If one adds 1,2,3,4,5,6 units of reagent, the jump from 1 to 2 is 1 unit but the concentration is increased x2. The jump from 5 to 6 is also 1 unit but the relative increase is only x1.2. For some studies it is better to arrange that each rise is proportionally the same. If your graph is then crowded at one end, try a non-linear scale. Convert doses to *log* doses or use *log* graph paper; or try reciprocals, squares or square roots; try dissimilar conversions for the two co-ordinates. Such conversion may use the graphic area more effectively, and it may reveal a straight line.

Numbering of figures, tables & references during their preparation

If you number the tables and figures from first writing you may have to change the numbers as your paper develops. Instead, give them letters that describe them to you privately. When all is ready for the *final* typing, change to consecutive numbers. By this scheme you are unlikely to leave a wrong number in the text. Literature cited poses an analogous problem. I use the Harvard System at first - names and year in the text. Then, if the journal requires a numbering system, I change to the latter at a late stage, with the help of gummed paper strips. The two systems are elaborated, for example, in the *Biochem.*J, (1973) **135,** 1-3.

Units & quantities

Use SI units. The Lithuanian, Frenchman or Brazilian has to understand English: dont add to his difficulties with oz,°F or p.s.i. Even if you built apparatus to inches convert them for description, but dont give a false impression of precision with non-significant digits. Now that ml (a sub-multiple of a sub-multiple) is obsolescent, some people, although they write 'cm^3', in speech ***say*** 'cc'. Units named after people are spelled without a capital, but symbols for such units do have capitals: thus watts & W, joule & J.

Modern units go up and down in steps of 1000. Avoid other steps where possible. The Angstrom is redundant. Concentrations other than molar are expressed as parts per thousand or per million etc. The symbol $^0/_{00}$ meaning per thousand, could be used more often.

The sign % indicates a ratio, a pure fraction with no unit element included. The expression 'mg%' meaning 'mg/100cm^3 of fluid' is not scientific. But that is not all. Does 'the blood sugar rose by 2%' mean 2 percentage units or x1.02? The order of magnitude may give a clue, but, if the reader takes no interest in decoding, the information is lost. It seems desirable to reserve percentage for comparisons. But they must be clear. Such expressions as 'rose by 250%', '92% less than', 'twice lower than' are sometimes used wrongly, and therefore always suspect. 3 times more than means 4 times as much as. Replace '150% more than' by '2 1/2 times'. It took a reader a long time to appreciate that 2.1/2 was not 1.05 but 2 1/2. The element of doubt makes it advisable to avoid such expressions. A test repeated ***n*** times was carried out ***n*+1** times. Never juxtapose numbers, but write, for example, 'twelve 3-day-old chicks' or 'six 100-cm^3 flasks'. Billion and trillion are best not used, because their

meanings are not the same in all countries.

Make your units unambiguous. Dont let us wonder - does /g mean of material or of dry matter? I dont apologize for repeating the plea for clarification of ±.

Time of day should be given on the 24-hour system. Dates are printed without punctuation - 5 June 1975 - or with hyphens - 5-VI-75 - or as three numbers - 05 06 75. To sandwich the day between bigger units is illogical. Logically one should proceed from general down to particular - year, month, day, hour, minute - but that is not yet with us, although it will come.

When you offer a series of values, dont repeat the units. Write '3 and 4g' not '3 g and 4g'. From 'the percentage was 8%' omit %. Similarly, prune 'the pH of the solution was pH8' and 'the voltage was 8V.

Apparatus, materials & writing techniques

To write well one must be in the right state of mind. Such a 'mood' cannot be commanded. Seating, desk, pen and paper can help. The chair should be of the right height and should offer firm back support at kidney height. This is to allow one to sit upright in comfort. (A crouching posture may lead to back-ache in later life.) (Read **Where to start**)

Because you may rewrite many times, a pen that glides easily is more than desirable. Ball-point pens are popular, but their product is relatively characterless, which may affect legibility. If you prefer a fountain-pen, choose a nib with care. Some authors write with a pencil, but, although corrections are easy, pencilled writing is hard to read. Spray a pencilled page with artist's gum to prevent blurring. You can write on it. Choose a paper that suits you. Write only on one side of the paper: writing on both sides makes rearrangement difficult. The top surface (the side from which the watermark reads the right way) is the smoother. Dont write much on a sheet—the pages need not be filled. Generous use of paper facilitates rearrangement of sections.

Alterations & corrections

To make a correction to a manuscript, stick paper over the error and write the new word on top. Gummed paper strips about 7mm wide are suitable. For bigger changes rewrite the passage on another sheet, cut the old page across and stick the new piece in place. Gum sticks quickly, paste is less messy.

Some people write on the right-hand side of folded sheets, leaving the left-hand side for insertions. The product is not so handy for the typist as that of the scissors-and-paste method. Alternatively one may write originally only on alternate lines.

After you have made many corrections to a script, copy out the untidiest page, using scissors and paste to avoid copying clean paragraphs. As you copy you will want to improve sentences. Rewriting is a better stimulus to making improvements than is mere reading. The effort of making the fair copy will have been worth while. Try it. Verify - or refute - the hypothesis experimentally. It is far, far better to make your corrections according to a scheme such as here described than to scribble across the script. The systematic scheme

permits, whereas the scribble scheme discourages, your re-reading of the new version.

If you type directly, or use a tape-recorder, do consider carefully whether you have made all the corrections you should. I have known authors reluctant to improve a typescript - because it would spoil the page.

The typescript

Most journals require wide margins and double spacing throughout, including footnotes, legends and notes to tables *.

> * The words in *italics* are often overlooked. The requirement is not editorial pomp: the space is needed for the copyrnarker's instructions to the printer, which are usually more numerous than in the text.

Typists' typography differs from printers' typography as to spacing and punctuation. [Unfortunately the typist may have had to type in that manner to pass her exams.] An editor or the printer's copyrnarker has to 'correct' the typescript. This takes time and makes the copy untidy. So do ensure clear typing with contemporary punctuation and spacing. The printer does appreciate good 'copy', as he calls the script. (See **Journey's end**) Please show your typist this page and also the piece on **Abbreviations**. Each paragraph should be indented, but no more than 2 spaces. Paragraphs that are not indented (for reasons of fashion?) risk being 'run on'. There is no need for extra space between paragraphs except to indicate a new section. All pages must be numbered, including the first.

Division of words at the end of a line should be minimized. If a hyphen appears there, the printer may join the parts of words. Suppose the hyphen is needed - as in dansyl-lysine - it is good practice to repeat the hyphen at the beginning of the next line. It is even better for the whole word to be carried over, the more so because broken words interfere with reading. The lines in a typescript do not have to be all the same length. Do the unequal lines of this text disturb you as much as divided words would?

The editor may request two clear copies. Blurred carbon copies strain the referee's eyes because he is continually attempting - abortively - to sharpen the image by focusing. If the typewriter's 'e' is full of stencil cuttings, please have them brushed out. You want clean proofs; so let the printer have clear copy. Photocopies include corrections made on the original, and they have other advantages over carbon copies; but such copies should not be submitted unless they are sharp.

In the margin, type 'Table .. near here'. Similarly for figures. Draw a ring round these and other instructions to the printer about Greek symbols, mathematical signs etc. Then he will not print the instructions! Such balloons are useful in other ways. If a correction or addition to the text is indistinct it may be confirmed by being written in the margin and ringed.

Cover sheet. Some editors appreciate your supplying a top sheet. On it type the *name of the journal, title of the paper, author(s), address (for correspondence), short title, number of figures and number of tables.*

Additions. When you retype a page, do take care that all has been copied. When I cannot understand a passage in a typescript I wonder - has a phrase been omitted? Jumps occur

when a typist 'picks up' a word in error at its repeat. (See 'tape ... tape' two sentences below.)

Dont join papers with pins or staples - they embarrass the printer. If you use transparent tape let it be the somewhat rare invisible mending tape. Common pressure-sensitive tape should not be used. The latter, convenient though it is for authors and secretaries, is disliked by editors and printers, comes unstuck and cannot be written on.

Drawing the diagrams for reproduction

To make a graph, draw the 'points' in ink. Sketch the curve first in pencil, freehand or against a flexible rule. You can then erase the curve for re-drawing without losing the points. Or you may be able to calculate the line of best fit.

Draw a diagram or graph at least twice the dimensions of the printed version. (If the directives say twice the *size,* that is probably an error.) Such enlargement demands thick lines, perhaps thicker than seems necessary to your eye. Ensure that lines in different diagrams will appear equally tilick, for example by using the same scale for all drawings.

The blockmaker likes drawings to be on bristol board, but graph paper is usually acceptable provided its lines are faint blue. Graph paper helps one to keep drawings of apparatus square. To transfer a diagram to bristol board, fix the former on the latter, then prick through principal points with a needle. The tiny holes provide a template for your drawing. They will be inked over, and should cause no trouble.

Line drawings are reproduced by an all-or-none process. So draw your lines densely black; faint blue lines, pencillings etc. may not appear. Deletions can be made with gummed paper. Thus a continuous curve can be made dotted or dashed by sticking narrow gummed strips over it at intervals. Drawings of apparatus may need to be hatched (shaded). Patterned paper can be bought for cutting to shape and sticking over particular areas. Some journals re-draw figures. However, make sure before you count on this.

Words or numerals may be written in pencil (clearly, please) on the diagram, or in ink on a transparent detachable overlay. Most printers can have such lettering inserted professionally. An inexperienced draughtsman has difficulty in making the letters of suitable size. Examine a journal with author-drawn letters and you will see that unsuitable lettering spoils a picture. If you draw your own letters, as for a thesis, use small letters (the printer calls them lower-case): they are more legible than capitals. Label each curve if possible, but briefly of course: seeking explanations in the legend is tiresome for the reader.

Journey's end for the script

If you write many papers or a book, visit a printing works. Such a visit will help you to understand what can be done and what is typographically costly. If you are shown examples of good and bad copy, you will see that the above disquisition on the preparation of a typescript is not too detailed. Further, you should see why alterations at the proof stage are expensive. The 'Ladybird' (Loughborough) book no. 13, *Printing Processes* explains what an author needs to know. The illustrations are excellent. The other Ladybird on printing, though interesting, is less suitable.

Preparation of a doctoral dissertation or thesis

Although a thesis differs from a scientific paper, most of this essay applies. The literature may be more fully reported. Discuss published work critically but not unkindly. Examiners like to know that you can evaluate other people's reports. Your inconclusive experiments may be described as a basis for suggestions about what might be done next. Indeed, unlike a scientific paper, a thesis is a suitable place in which to propose experiments to test a hypothesis. [But see Promises ✔.] Intelligent speculations, too, may have a place in a thesis.

When you set out a thesis, consider the reader. Dont merely copy another thesis. Examine good books and arrange your thesis as a printer would: write many headings and make a clear distinction between different sorts; be sparing in the use of full stops; leave ample margins, with that at the foot greater than that at the top - a niggardly bottom margin makes the page seem to be sliding off the paper. Read above ✔. Be meticulous over punctuation: there will be neither editor nor printer to put that in order. Remember that examiners who find sloppy details may suspect sloppy experiments.

Give a *complete* table of contents at the beginning - but dont call it an index - and another of figures. The **Summary** should come before the **Introduction.** It is better to make many small tables than a few large ones. Place them, and the diagrams, as near as you can to the relevant text. Arrange both upright: readers dislike having to turn books sideways.

If you heed the advice given under **When to begin** you must begin writing your thesis before you are two-thirds through your course. You may think that absurd because you have so few results. Even so, you you can start on certain parts, as suggested above. The examiners may be seeking to answer the questions *'Does this student know how to set about a problem? Can he think?'* rather than *'Has he done many experiments?'*

Every research student - and other writers too - should read Kitson Clark (1960) on preparing for research. The prose is a joy to read.

Good sense

When you meet good writing, study it, try to emulate it. Many of us use but 3% of the words in the Oxford English Dictionary. Through attentive reading you can enlarge your vocabulary. This will help you to overcome a principal difficulty in writing - finding the right word. When you have this difficulty (quandary, problem, doubt, perplexity, dilemma ...), write alternatives [as here and above ✔] in the margin. At a later reading you may be able to choose (select, reject, pick, exclude ...) suitably. If no word fits, consult Roget's *Thesaurus;* there are several editions. If you meet a 'new' word you like, do look it up in a dictionary before you use it. Careless use weakens words. (See examples of careless use under **Choice of words**)

Read other people's writings critically. Even edit them - but not in library books! You may obtain amusement by collecting absurdities, and this will help you to be vigilant in avoiding them in your own writing. Here are some:

> solid line;
> absent in the solution (write 'from');

molar $CuSO_4,5H_2O$;
Ibs;
the kind gift;
centred around;
at varying temperatures in a thermostat (write 'various');
most probably (i.e. P = 1);
experiments were done in this paper;
bursts of activity could be seen following doses of atropine;
our records show that you do not exist.

Emotion & modesty in scientific writing

May I suggest that you avoid emotion in scientific papers? 'Great importance','significant conclusions' and similar expressions should be restrained. If you are tempted to write 'this most interesting result' ask yourself 'To whom is it most interesting?' Strunk says *'Instead of announcing that what you are about to tell is interesting, make it so'.*

If he published first, dont say 'Lea confirmed my result' but 'my result is in accord with that of Lea'. Although you have to mention your publications as necessary, dont let the **Bibliography** look like a personal history.

An author who writes 'we were surprised' or 'unexpected result' admits lack of knowledge. For, he who knows all can predict all. Humility is good but may not be the author's intent.

Promises should be offered sparingly. An author who writes that an idea will be investigated may be warning you off 'his' territory.

Are rats killed or sacrificed?

If you list arguments as 'first, ... second, ...' dont call the last 'finally'. You can rarely be certain the subject is closed ✔. Of course we hope - but privately, not in a scientific paper.

Addressed to writers for whom English is a second or foreign language

Certain errors occur often enough in translations to warrant mention.

'Remarkable' means worthy of note: the writer may mean marked, striking or pronounced. For 'remarkably' he may mean markedly.

'To control' does not mean to count, measure or monitor. It means to command, govern, maintain (temperature) or limit (speed) ✔.

Dont omit 'that in' from 'growth was similar to that in the controls'.

You compare or contrast with not to.

'Also' commonly occurs in a wrong place: often the best place is next before the main verb.

So does 'already': the editor may delete it because it is rarely needed in translation.

Dont use 'insignificant' biometrically; say 'not statistically significant' and quote the P value. If you have no P value, it may be better to write 'negligible'.

'This permits to do that' needs an object after 'permits'; e.g. 'us' or 'one'.

Dont write 'black respectively red' but 'black and red respectively', and dont abbreviate to 'resp.'.

You do not 'charge a solution onto a column'; you apply or place it there.

'Dosis' is not in common use; write dose.

'Would' and 'could' occur too often ✔.

Certain words are commonly misspelled: occurred, homogeneous, administered, synthesize, subtract, naphthol, phthalic, desiccate, focused, oxidation.

Dont break words at line ends; put the whole word on the next line.

For your comfort may I add that Englishmen also find it difficult to write good English ?

Further reading

The Royal Society's *General Notes on the Preparation of Scientific Papers* (6 Carlton House Terrace, London SWIY 5AG) should be studied by scientific writers.

A. J. Kirkman (1966), in *Preparing Papers for Scientific Journals* (Exp. Agr. 2, 147-160), gives hints on making a skeleton and on other matters.

Most journals issue Directives to authors. A good example, obtainable free from *Biochimica et Biophysica Acta* (Elsevier Publishing Company, P.O. Box 1345, Amsterdam, The Netherlands), gives help on chemical nomenclature and references to books. The Biochemical Society's *Instructions to Authors* (1975), which includes a piece on Policy and a useful list of abbreviations, symbols etc., appears in the *Biochem. J.* (145, 1-20) but can be purchased separately (Biochemical Society, 7 Warwick Court, London WCIR 5DP). The *Journal of Nutrition's Guide for Authors* (9650 Rockville Pike, Bethesda, Md. 20014, U.S.A.) includes firm but brief instructions about typing.

D. A. B. Young's (1969) *Instructions to Authors regarding Symbols and Abbreviations (Diabetologia* 5, 4-8) contains two tables of symbols and a piece on English of particular use to writers overseas.

Handbook for Chemical Society Authors is out of print, but is worth consulting if a copy can be found. There are many others.

Scientific Writing for Graduate Students (1970), edited by F. P. Woodford(Macrnillan, London), is excellent, but is addressed to the teacher. This book gives a list of other books.

K.W.Houp & T.E. Pearsall (1968), in their *Reporting Technical Information* (Glencoe Press, Collier-Macmillan, London), include an entertaining chapter on writing in clear English and on 'empty words'.

Guide for Research Students working on Historical Subjects (1960 or later edition) by G.KitsonClark (Cambridge University Press) is included here because it is an example of written English at its best.

H. W. Fowler's *Modern English Usage,* as edited by E. Gowers (Oxford University Press) or by M.Nicholson *(American-English Usage,* Oxford University Press Inc., New York), is invaluable.

E. Partridge's *Usage and Abusage: a Guide to Good English* (Hamilton, London) is preferred to Fowler by some editors.

What a Word! by A. P. Herbert (Methuen & Co., London), who calls you Bobby, shows that good style need not be dull; and B.Dixon (1973) in *Sciwrite* (Chem.Brit. 9, 70-72) urges lively writing and gives examples ofstuffiness.

W. Strunk in *The Elements of Style* (various editions, e.g. with E. B. White, Macrnillan Co., New York) urges you to write in simple style with the minimum of words.

The *Concise Oxford Dictionary* (Oxford University Press) is admirable.

Chambers' Twentieth Century Dictionary (Chambers, Edinburgh) is more clearly printed.

Every scientist should have *A Dictionary of Science* by E. B. Uvarov, D.R. Chapman & A. Isaacs (Penguin Books, London).

Chambers's Dictionary of Science & Technology (Chambers, Edinburgh), which is larger, is well described by its title.

For American spelling consult, for example, *Webster's New Collegiate Dictionary of the English Language* (Merriam, Springfield, Mass.).

IUPAC (International Union of Pure and Applied Chemistry) Rules for nomenclature of chemicals are given in *Nomenclature of Inorganic Chemistry* (2nd edition) (1971) and *Nomenclature of Organic Chemistry* (combined and revised edition) (1971) (both published by Butterworths, London). For a check on spelling of chemical names you may consult a well-produced catalogue of chemicals.

D. Margerison (1973) has written *SI Units: an Explanation of the International System of Units* (free, from Koch-Light Laboratories Ltd, Coinbrook, Bucks.), but for definitive publications see *Pure Appl.Chem.* (1970) 21, 1-44, and *Quantities, Units and Symbols* (1971) (The Royal Society, London).

Ñì. òàêæå *Ñ.Ñ. Êóòàòåëàäçå*, "Russian-To-English To Writing"

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